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PRODUCTION ENGINEERING MEASURE FOR HIGH RANGE GEIGER MUELLER TUBE

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LND, Incorporated
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"PRODUCTION ENGINEERING MEASURE FOR HIGH RANGE GEIGER MUELLER TUBE."

"SECOND QUARTERLY REPORT COVERING THE PERIOD FROM SEPTEMBER 1972 TO NOVEMBER 1972".

"THIS PROJECT HAS BEEN ACCOMPLISHED AS PART OF THE U.S. ARMY ADVANCE PRODUCTION ENGINEERING PROGRAM, WHICH HAS AS ITS OBJECTIVE THE TIMELY ESTABLISHMENT OF MANUFACTURING PROCESSES, TECHNIQUES OR EQUIPMENT TO INSURE THE EFFICIENT PRODUCTION OF CURRENT OR FUTURE DEFENSE PROGRAMS FOR HIGH RANGE GEIGER MUELLER TUBES."

CONTRACT NUMBER DAAB05-72-C-5869

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ABSTRACT

AN INVESTIGATION OF THE PROPER TECHNIQUES EMPLOYED TO PROVIDE STABLE, PREDICTABLE PERFORMANCE, G-M TUBES FOR USE AS THE HIGH RANGE DETECTOR OF THE AN/VDR-1. THE TECHNIQUES INCLUDE SPECIAL CATHODE AND ANODE SURFACE TREATMENT TO PREVENT SECONDARY EMISSIONS AND RESULTANT SPURIOUS COUNTS (INSTABILITY) AND UP-DATED OUTGASSING AND FILLING PROCEDURES TO IMPROVE GAS STABILITY AND REDUCE ABSORPTION THEREBY IMPROVING VOLTAGE STABILITY.

ONE SET OF ENGINEERING TEST SAMPLES WAS FABRICATED DURING THE FIRST QUARTER USING 90MG/CM^2 WALL MATERIAL. TESTS SHOWED THAT PLATEAU CHARACTERISTICS WERE WITHIN SPECIFICATION BUT STARTING VOLTAGE DROPPED APPROXIMATELY 30 VOLTS.

IN THE TIME PERIOD OF THIS REPORT A SECOND SET OF ENGINEERING TEST SAMPLES WAS FABRICATED AND FILLED TO A STARTING VOLTAGE RANGE OF 430 ± 10 VOLTS. INITIAL TESTS DATA INDICATES A TREND TOWARD ACHIEVING THE REQUIRED CRITICAL PARAMETER OF STARTING VOLTAGE STABILITY.

PURPOSE

THIS IS THE SECOND QUARTERLY REPORT UNDER CONTRACT No. DAAB05-72-C-5862. PRODUCTION ENGINEERING MEASURE FOR HIGH RANGE GEIGER MUELLER TUBES. THE PURPOSE OF THIS PROGRAM IS TO DEVELOP A PRODUCTION METHOD AND ASSOCIATED DOCUMENTATION FOR THE HIGH RANG G-M DETECTOR USED IN THE AN/VDR-1 RADIAC EQUIPMENT.

DURING THIS REPORTING PERIOD EFFORT HAS BEEN EXPENDED ON THE FOLLOWING AREAS:

A. REVISION OF FABRICATION PROCEDURE FOR ENGINEERING TEST SAMPLES.

B. PREPARATION OF SECOND SET OF ENGINEERING TEST SAMPLES.

C. TEST OF FIRST AND SECOND GROUP OF ENGINEERING TEST SAMPLES.

D. REVIEW OF TEST DATA.

E. PREPARATION OF REVISED PRODUCTION PROCEDURES.

F. PREPARATION OF REVISED G-M TUBE FABRICATION PROCEDURE.

STATEMENT OF THE PROBLEM

THE FABRICATION OF THE HIGH RANGE DETECTOR USED IN THE AN/VDR-1 EQUIPEMENT HAS PRESENTED SEVERAL DIFFICULT AREAS OF TUBE PARAMETERS TO BE MAINTAINED AND STABILIZED OVER THE TUBE LIFE. AS DISCUSSED IN THE PREVIOUS REPORT THE MOST DIFFICULT PARAMETERS ARE:

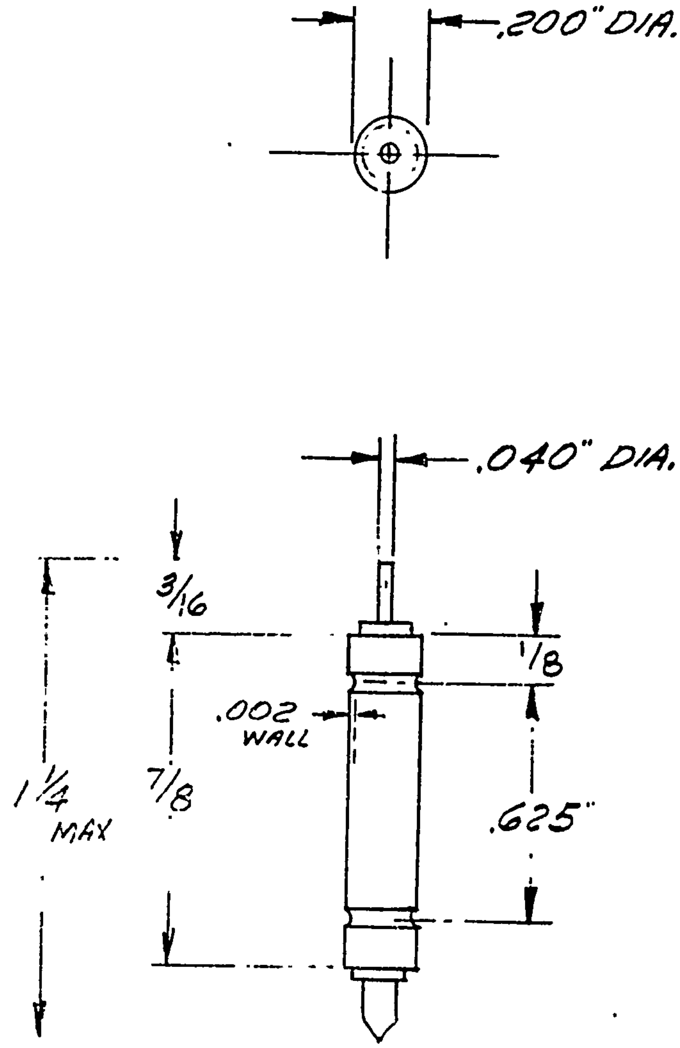
1. STARTING VOLTAGE.
2. GAMMA SENSITIVITY.
3. MINIMUM PULSE AMPLITUDE.
4. REPRODUCIBILITY FROM TUBE TO TUBE.

THE GAMMA SENSITIVITY IS GIVEN BY THE PHYSICAL SIZE OF THE DETECTOR ITSELF (FIG. 1 AND PHOTOGRAPH 1) AND WILL NOT BE DISCUSSED.

THE MINIMUM PULSE AMPLITUDE WAS SHOWN IN THE FIRST GROUP OF ENGINEERING TEST SAMPLES AS NOT BEING A PROBLEM.

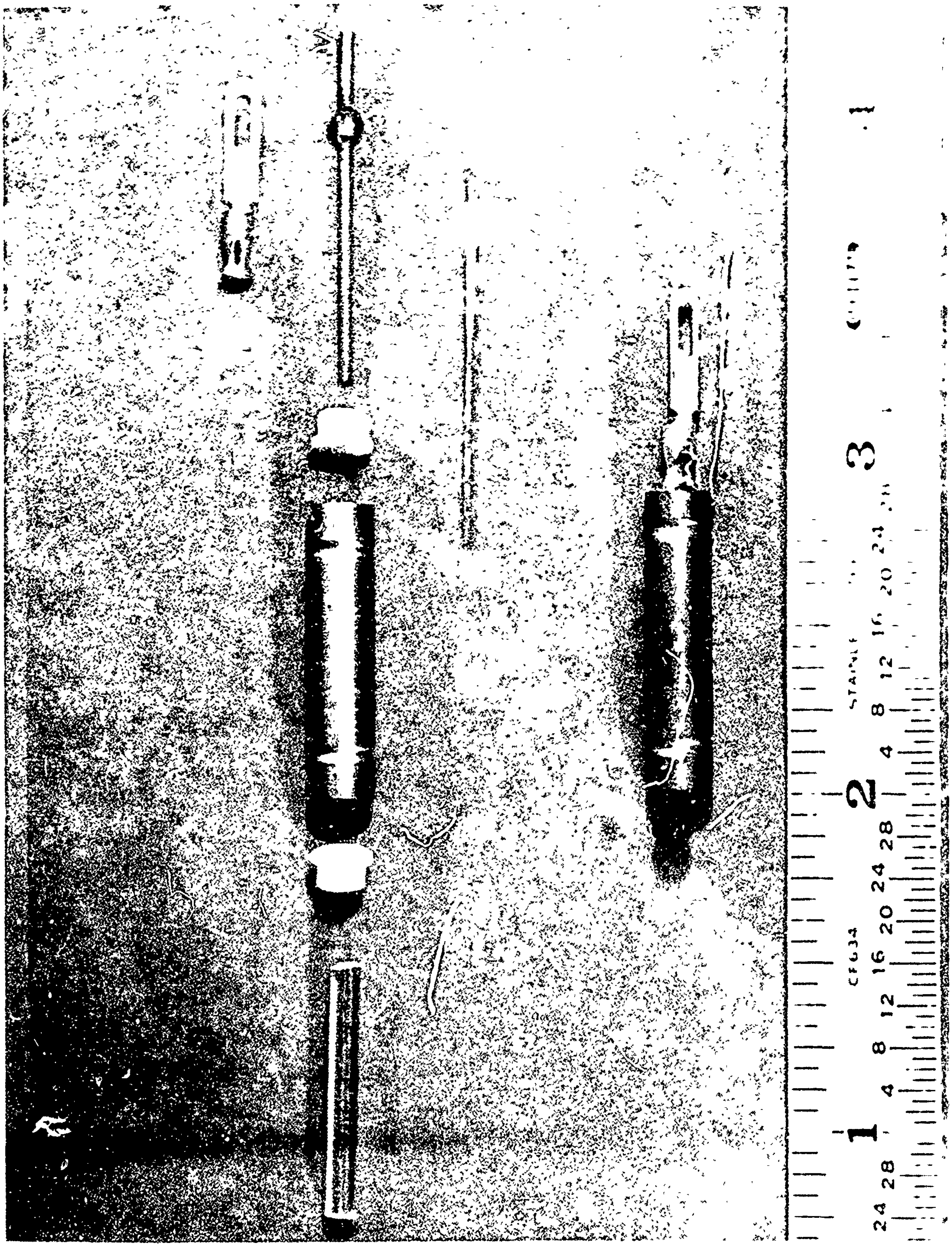
INCLUDED IN THE REVISED FABRICATION PROCEDURE IS CONSIDERATION AND ANALYSIS OF THE PHYSICAL PROPERITIES AND MATERIAL CHARACTERISTICS THAT CONTROL EACH OF THE CRITICAL PARAMETERS AND IN ADDITION THE REMAINING TUBE PARAMETERS REQUIRED BY THE SPECIFICATION. EFFECTIVELY THE CONTROL OF CRITICAL PARAMETERS REDUCES TO THE TASK OF DEVELOPING THE APPROPRIATE TECHNIQUES FOR:

A. ELIMINATING THE PROBABILITY OF SECONDARY EMISSION OF ELECTRONS FROM THE CATHODE SURFACE.



Outline of GM Counter

Figure 1



Photograph 1 - Components and Assembled Unit

B. THE INTRODUCTION OF PROPER GAS FILL MIXTURE TO EXHIBIT THE REQUIRED "STARTING VOLTAGE AND TUBE DEAD TIME."[1]

THE APPROACH PURSUED DURING THIS REPORTING PERIOD CENTERED ON REVISING THE NEEDED CONTROLS OF THE ABOVE TECHNIQUES WHILE FABRICATING TUBES OF THE SIZE AND SHAPE AS SHOWN IN FIGURE 1 AND PHOTOGRAPH 1.

THE CONTROL OF THE SURFACE OF THE ANODE AND CATHODE IS ACCOMPLISHED BY THE LND PROPRIETARY PROCESS OF PASSIVATING THE CATHODE (APPENDIX).

AFTER THE CATHODE AND ANODE PASSIVIATION THE DETECTORS ARE THEN ASSEMBLED USING THE FOSTERITE CERAMICS AND POWDERED GLASS. THE ASSEMBLY PROCEDURE IS AS FOLLOWS:

1. CLEAN ALL COMPONENTS PER LND SPEC. M-900260 (APPENDIX)
2. PLACE ANODE IN INSULATOR AND PLACE ASSEMBLY IN CATHODE.
3. PAINT POWDERED GLASS FRIT OVER ANODE INSULATOR JOINT AND INSULATOR CATHODE JOINT.
4. PLACE IN FIRING FIXTURE AND FIRE IN AIR OVEN AT A TEMPERATURE OF 600°C.
5. AFTER FIRST FIRING PLACE REAR INSULATOR INTO TUBULATION AND PLACE ASSEMBLY INTO CATHODE.
6. REPEAT STEPS 3 AND 4.

[1] The required values are Vs = 400 volts, dead tiem = 20μsec

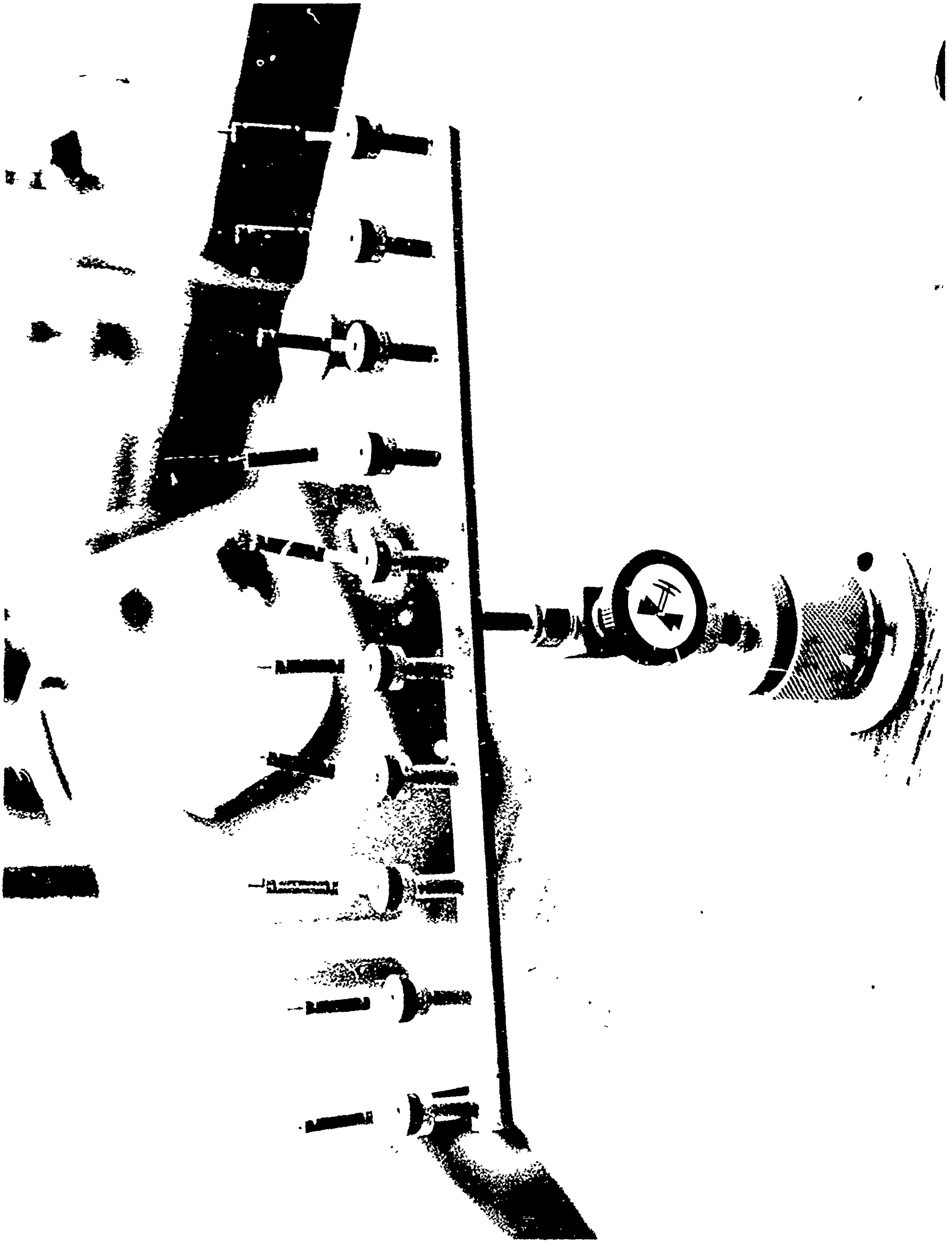
THE ASSEMBLED UNITS ARE THEN LEAK CHECKED ON A HELIUM MASS SPECTROMETER ACCORDING TO LND SPECIFICATION M500140BA USING A SPECIAL FIXTURE AS SHOWN IN PHOTOGRAPH 2 ALLOWING MULTIPLE LEAK CHECKING OF THE DETECTORS. USING LND FIXTURE 4130 FIGURE 2 WE CAN NOW LEAK CHECK 10 UNITS IN LITTLE MORE TIME THAN IT PREVIOUSLY TOOK TO LEAK CHECK ONE UNIT. KEEPING IN MIND THE END REQUIREMENT OF A PRODUCTION CAPABILITY AT LOW COST WE ARE ATTEMPTING TO MODIFY EXISTING FACILITIES. AFTER LEAK CHECKING THE ASSEMBLED UNITS ARE THEN STORED IN A HEATED DESSICATED CABINET UNTIL INSTALLED ON THE PUMP.

LND MANUFACTURED 30 UNITS WHILE MAKING THE FIRST GROUP OF ENINGEERING TEST SAMPLES. THE DISPOSITION OF THESE UNITS WAS AS FOLLOWS:

12 UNITS - SERIAL # 27914, 27912, 27908, 27919, 27909, 27925, 27902, 27931, 27918, 27907, 27930, 27928 - WERE SHIPPED AS THE FIRST GROUP OF ENGINEERING TEST SAMPLES.

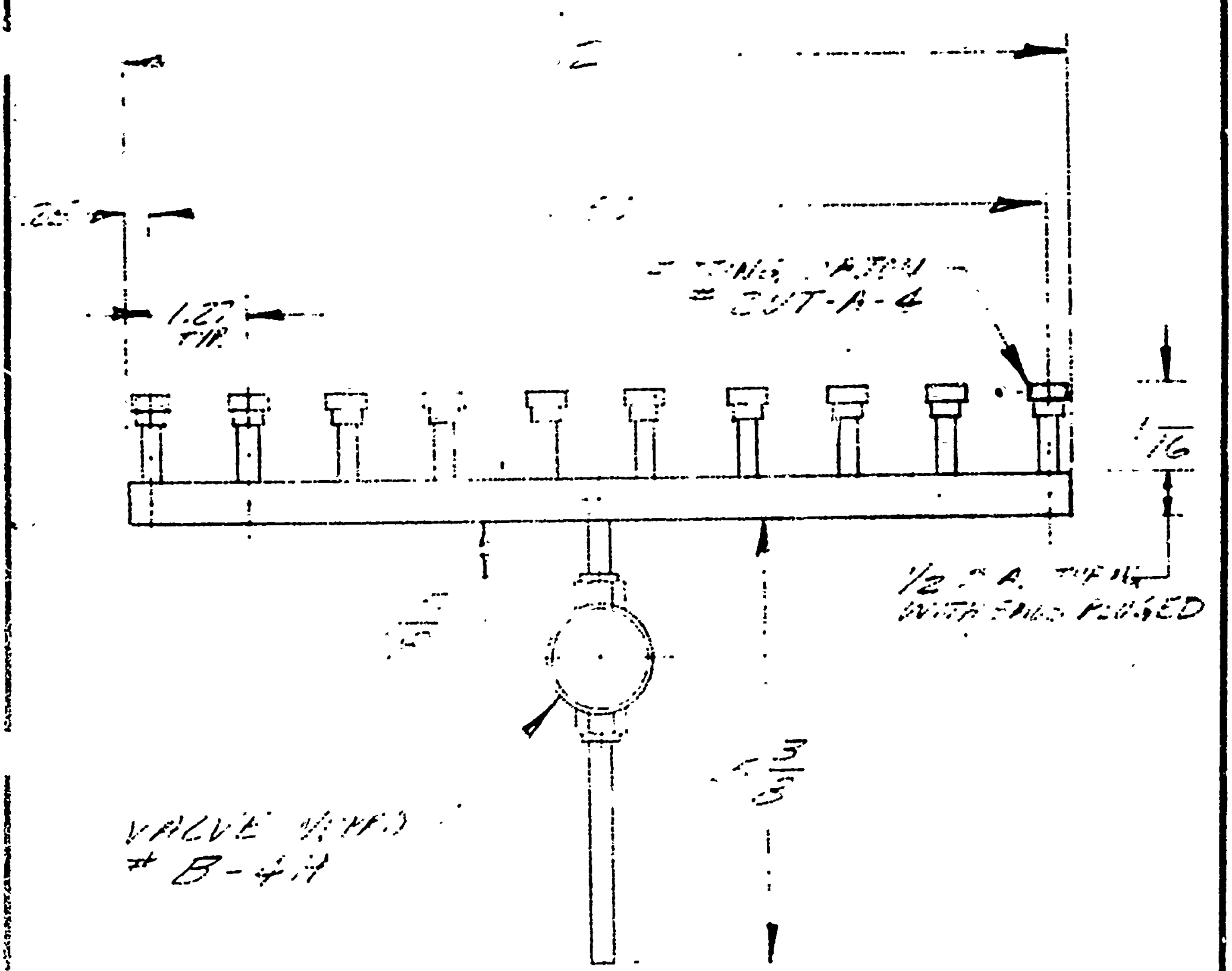
4 UNITS - SERIAL # 27915, 27927, 27929 AND 27928 WERE SHIPPED TO NUCOR FOR EVALUATION IN PULSED OPERATION.

2 UNITS - SERIAL # 27913 AND 27906 FAILED IMMEDIATELY, 27913 DEVELOPED A LEAK, 27906 WAS BROKEN IN HANDLING.



Photograph 2 - Multiple Leak Testing Manifold

REV	DESCRIPTION	DATE	APPD



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MATERIAL	TOL UNLESS OTHERWISE SPECIFIED	LND, INC. 3230 LAWSON BLVD. OCEANSIDE, N. Y.		
BLANK SIZE	FRAC ± 1/64 DEC ± .005 ANG ± 1°			
	SCALE 1/2	TITLE 10 PLACE MANIFOLD		
DRAWN BY	REF	TUBE TYPE	PART NO. F4130	REV
APPV'D BY				

Serial No.	Vs.	550V	600V	650V	700V
27973	Leaks				
27922	Oscillates				
27929	400V				
27923	Oscillates				
27920	Oscillates				
27904	Oscillates				
27911	400				
27927	500				
27926	Oscillates				
27917	500				
27924	400	3206	2038	5848	
27906	Leak				
27916	Oscillates				
27910	400				

FIRST GROUP OF ENGINEERING TEST SAMPLES
FINAL TESTING

Table 1.

OF THE REMAINING TUBES AT LND FROM THE FIRST GROUP OF ENGINEERING TEST SAMPLES ALL FAILED BY THE END OF THIS REPORTING PERIOD. SEE TABLE 1.

THE FINAL TEST DATA SHOWN IN TABLE 1 SHOWS THE INSTABILITY OF THE COUNTER WITH REFERENCE TO STARTING VOLTAGE.

INITIALLY THE STARTING VOLTAGE DROPPED APPROXIMATELY 30 VOLTS FROM A TIP OFF VOLTAGE OF 375 VOLTS TO APPROXIMATELY 340 VOLTS SEE TABLE 2.

THREE MONTHS LATER THE UNITS REMAINING AT LND WERE ALL INOPERATIVE WITH STARTING VOLTAGE OF 400 VOLTS OR IN OSCILLATION.

THIS IS DUE TO IMPROPER QUENCHING WHICH IN THIS CASE IS CAUSED BY THE ABSORPTION OF THE HALOGEN QUENCH GAS INTO THE CATHODE AND ANODE. DUE TO THE EXTREMELY LOW HALOGEN PRESSURE USED (7 TORR) IT IS NECESSARY TO FURTHER PROCESS THE INTERNAL ANODE AND CATHODE SURFACE TO REDUCE ITS HALOGEN ABSORPTION. THIS WAS ACCOMPLISHED WITH THE SECOND GROUP OF ENGINEERING TEST SAMPLES USING THE FOLLOWING FILL SCHEDULE ON A SYSTEM AS SHOWN IN FIGURE 3 AND PHOTOGRAPH 3 AND 4.

Serial Number	Starting Voltage	Deviation From Required Vs.
27914	337 volts	-53 volts
27912	336	-54
27908	333	-57
27919	333	-57
27909	331	-59
27925	329	-61
27902	336	-54
27931	328	-62
27918	332	-58
27907	327	-63
27930	331	-59
27928	333	-57

INITIAL STARTING VOLTAGE DROP AND DEVIATION
FROM NORM

Table 2

1. Fuse on tubes and evacuate the manifold with roughing pump. After 5 minutes check vacuum by sparking.
2. Place liquid nitrogen around cold trap and switch manifold to high vacuum pumping system.
3. When vacuum is less tha 2×10^{-4} torr shift oven shield over the tubes and increase the temperature slowly (greater than 30 minutes) until 400°C. Leave at this temperature for 48 hours and until a vacuum of 5×10^{-7} on the manifold is reached. When proper vacuum is reached, let oven cool to 185°C admit 12 torr Cl_2 - soak for one hour and let oven cool to room temperature and remove oven cover.
4. Pump out Cl_2 for 10 minutes ($<10^{-7}$ torr).
5. Spark the cathode of each tube for a period of one minute.
6. Pump out for 10 minutes ($<10^{-7}$ torr).
7. Place 3 torr Cl_2 in detector, Cl_2 spark anode and cathode one minute each.
8. Pump out for 10 minutes ($<10^{-7}$ torr).
9. Close high Vacuum pumping system and open valve to filling manifold.

NOTE: All underlined segments are different from first filling procedure.

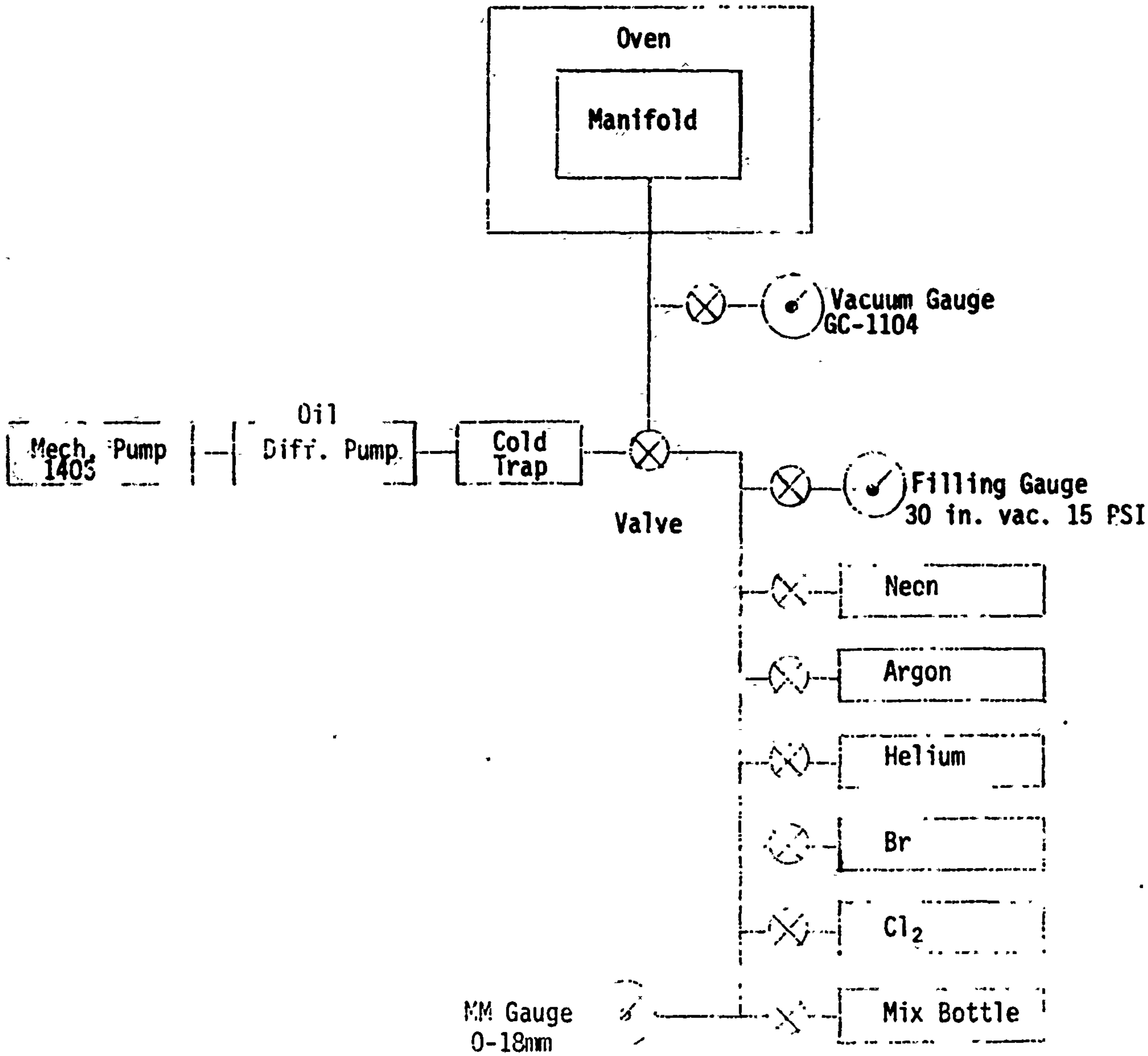
10. ADMIT 7 TORR BROMINE INTO MIXING BOTTLE. ADD NEON ADMIXTURE TO MIXING BOTTLE TO A PRESSURE OF 500 TORR. LET BROMINE AND NEON ADMIXTURE SATURATE FOR 5 MINUTES IN MIXING BOTTLE.

11. LET GAS MIXTURE INTO TUBE MANIFOLD UNTIL PRESSURE IN DETECTORS IS 175 TORR.

12. AFTER 5 MINUTES, MELT OFF TWO TUBES AND GIVE TO TESTING FOR EVALUATION.

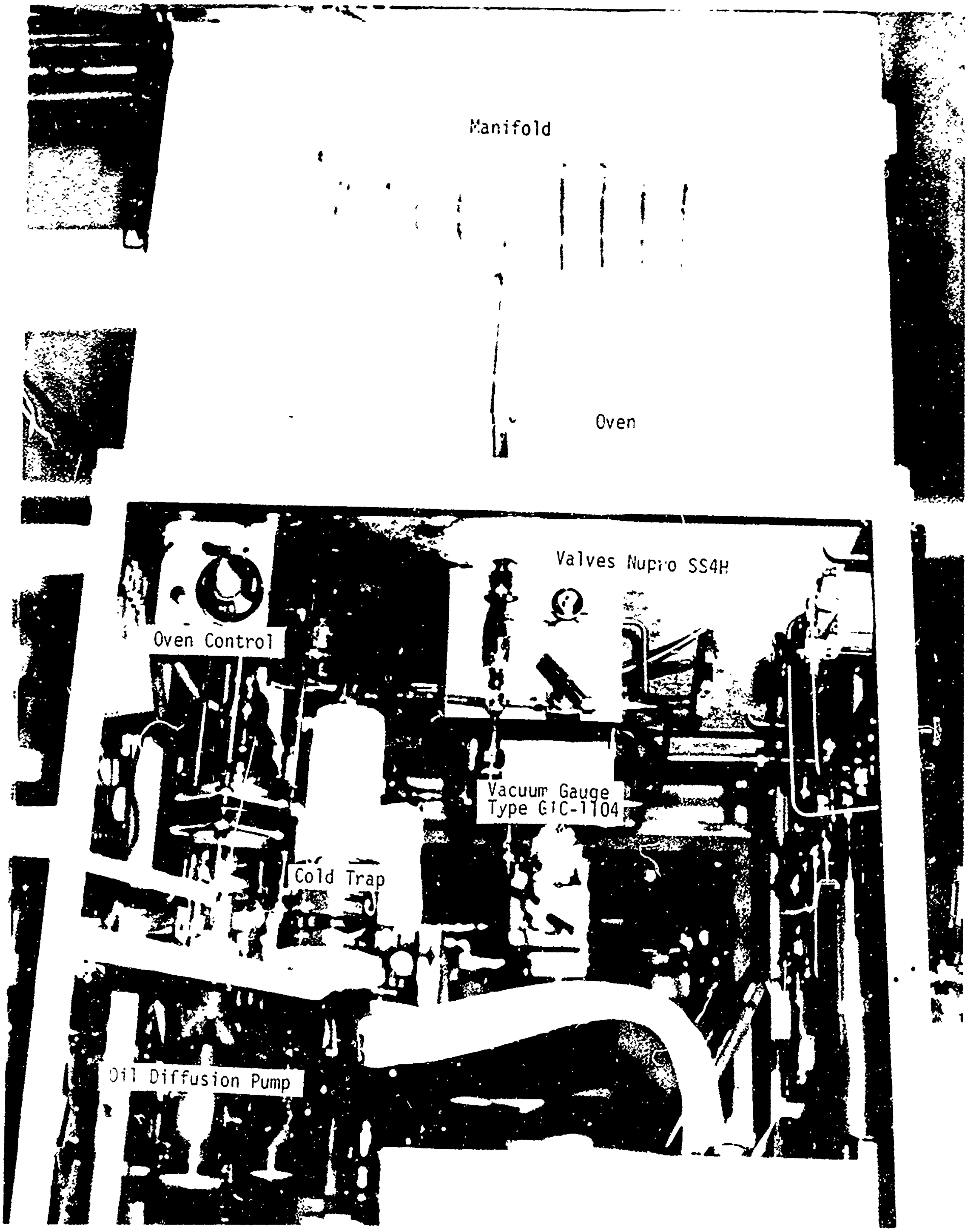
THE CL_2 SOAK IS DONE TO FURTHER PASSIVATE THE CATHODE AND ANODE TO REDUCE THE HALOGEN ABSORPTION AFTER FINAL FILL. THIS PROCEDURE HAS BEEN DEVELOPED INDEPENDENTLY BY MANY DIFFERENT TUBE MANUFACTURERS AND MODIFIED TO SUIT INDIVIDUAL TUBE APPLICATIONS.

WHEN THE TUBES AND MANIFOLD ARE BEING PUMPED AND BAKED, HEATER TAPE IS PLACED AROUND THE MIX BOTTLE AND FILLING MANIFOLD. THIS IS THEN PUMPED AND BAKED WITH THE TUBES.

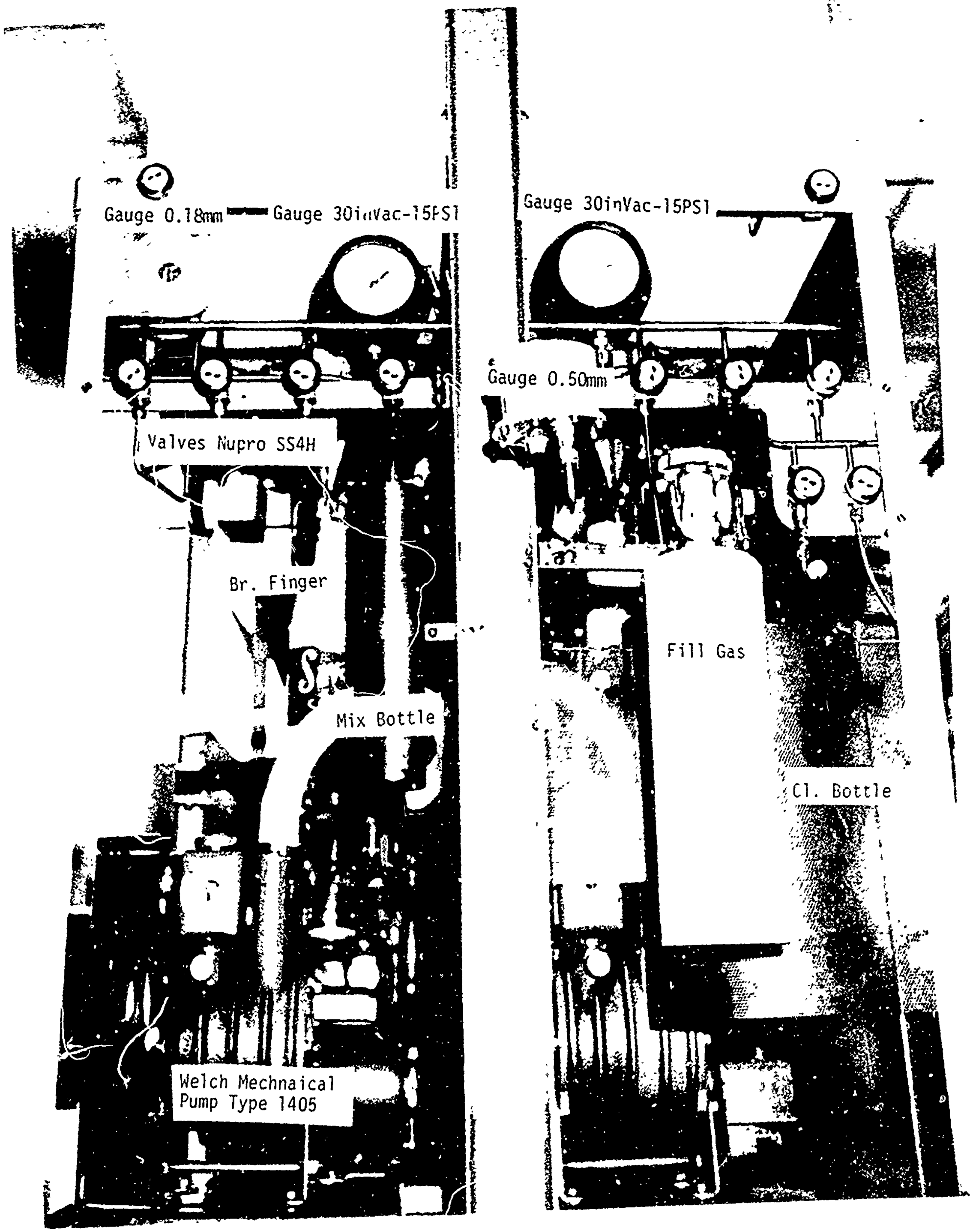


GM COUNTER PUMPING AND FILLING SYSTEM

FIGURE 3



PHOTOGRAPH 3 - PUMPING SYSTEM



PHOTOGRAPH 4 - FILLING SYSTEM

Chlorine Processing

The electronic configurations of the halogens are listed in Table 3. Each of the halogens differs from the inert gas that follows it in the periodic system by having one less electron in its balance shell. These elements are all nonmetals, since the atoms have a strong tendency to attain the stable inert gas configuration (and an oxidation state of -1) either by taking up an electron from an atom of a metallic element to form a singly charged negative ion, or by sharing electrons with elements whose tendency to release electrons is not sufficiently great to allow electron transfer.

Under ordinary conditions all the halogens form diatonic molecules. This is a result of the fact that by sharing a single pair of electrons between them two halogen atoms attain stable configurations of minimum energy.

The halogens have very little tendency to lose electrons to form positive ions. This reluctance to form positive ions is understandable in terms of the high ionization potentials of these elements as shown in Table 4. The intermolecular forces in the free halogens are very weak and each substance is highly volatile. This is shown in the boiling and freezing points of the halogen (Table 5).

At room temperature chlorine is a greenish yellow gas, bromine is a deep brownish liquid which readily volatilizes to a reddish brown vapor. Bromine is one of only two elements which are liquid at room temperature.

Element	1	2	3	4	5	6
	S	S P	S P D	S P D F	S P D	S P
F	2	2 5				
Cl	2	2 6	2 5			
Br	2	2 6	2 6 10	2 5		
I	2	2 6	2 6 10	2 6 10	2 5	

Electron Configurations of Halogens

Table 3

Element	For 1 Electron	For the 7th Valence Electron
F	18.6	184.26
Cl	12.96	113.7
Br	11.80	- - -
I	10.6	- - -

Ionizations Potentials (Volts)

Table 4

Chlorine reacts directly with all the metals for form metal halides. Bromine which has less attraction for electrons than chlorine is less reactive and forms metal halides with all except the very noble (unreactive) metals.

Since the electron affinities of the halogens decrease in the order F>Cl>Br>I, chlorine has less tendency than bromine to be covalent. The oxidizing strength of the halogen decreases in the order $F_2>Cl_2>Br_2>I_2$ it is not surprising that the reaction of chlorine with a metal capable of assuming more than one oxidation state results in the formation of a chloride corresponding to one of the higher oxidation states.

Preparation of the Second Group of Engineering Test Samples

Components for the second group of twelve (12) engineering test samples were ordered and received.

The components include:

1. Cathode (machined part).
2. Anode (manufactured at LND).
3. Anode bead (manufactured at LND).
4. Front insulator (Duco Ceramics).
5. Rear insulator (Duco Ceramics).
6. Glass tubulation (LND commercial product).
7. Ground strap (LND commercial product).

The above components are shown in Photograph 1 and Figure 1.

8. ANODE PIN (LND COMMERCIAL PRODUCT).

9. POWDERED GLASS (LND COMMERCIAL PRODUCT).

ALL ITEMS WERE INSPECTED ACCORDING TO LND INCOMING INSPECTION PROCEDURES TO INSURE THAT COMPONENTS WERE THE PROPER MATERIAL AND WITHIN THE TOLERANCES REQUIRED IN OUR BASIC ENGINEERING DRAWING AND REQUIREMENTS SET DOWN IN THE HIGH RANGE G-M COUNTER SPECIFICATION.

THE TUBES WERE FABRICATED USING THE PROCEDURE DESCRIBED EARLIER.

TESTING OF SECOND GROUP OF ENGINEERING TEST SAMPLES

THE SECOND GROUP OF TUBE SAMPLES (12) WERE TESTED FOR THE FOLLOWING CHARACTERISTICS:

1. STARTING VOLTAGE (ROOM, ELEVATED, AND REDUCED TEMP.).
2. PULSE HEIGHT (ROOM, ELEVATED, AND REDUCED TEMP.)
3. PLATEAU CHARACTERISTICS (ROOM TEMPERATURE).
4. PLATEAU CHARACTERISTICS AT ELEVATED AND REDUCED TEMPERATURE.
5. RISE TIME AND DEAD TIME CHARACTERISTICS.
6. BACKGROUND.
7. CAPACITANCE.
8. LINEARITY.
9. BETA SENSITIVITY.

THE TEST DATA AND PRELIMINARY CONCLUSIONS FOR EACH TEST IS PRESENTED IN THE FOLLOWING TEST SUMMATIONS.

THE DETECTORS WERE INITIALLY FILLED TO A STARTING VOLTAGE OF 420 ± 10 VOLTS. THE VS. REMAINED BASICALLY CONSTANT AFTER TIP OFF FOR A PERIOD OF 24 HOURS.

ALL OF THE SAMPLES TESTED FAILED THE STARTING VOLTAGE SPECIFICATION. NONE OF THE SAMPLES TESTED FAILED THE PULSE HEIGHT AT 500 VOLT REQUIREMENT.

THE PLATEAU DATA WAS TAKEN AS SHOWN IN TABLE 5. ALL OF THE DETECTORS HAD A PLATEAU SLOPE OF <15%/100 VOLTS AND PLATEAU LENGTH OF >200 VOLTS.

THE PLATEAU DATA WAS NOT TAKEN IN A FIXED FIELD UNDER EXACTING CONDITIONS THEREFORE THE COUNT RATE CANNOT BE RELATED TO A RADIATION FIELD.

THE PLATEAU TEST WAS PERFORMED 1 MONTH LATER TO DETERMINE THE DROP IN STARTING VOLTAGE IF ANY AND THE CHANGE IN PULSE HEIGHT AT 500V ONE MONTH AFTER PREVIOUS TEST. ALL THE DETECTORS EXHIBITED APPROXIMATELY THE SAME STARTING VOLTAGE AS WHEN TESTED ONE (1) MONTH PREVIOUSLY. THE PULSE HEIGHT AT 500 VOLTS WAS WITHIN THE REQUIRED 30 ± 5 VOLTS.

	VOLTAGE			
SERIAL NUMBER	550	600	650	700
211234	5332	5524	6327	6208 CPM
211259	7461	7770	7898	8022 CPM
211241	4662	4962	5028	5227 CPM
211250	4332	4642	4662	4662 CPM
211240	4330	4422	4490	4580 CPM
211252	5557	5664	5882	6110 CPM
211254	4600	4872	4642	4924 CPM
211245	5021	5092	5362	5572 CPM
211239	4330	4508	4677	4721 CPM
211251	4510	4660	4672	4760 CPM
211244	4086	4102	4209	4270 CPM
211246	4902	5160	5262	5379 CPM

PLATEAU CHARACTERISTICS OF SECOND SET OF ENGINEERING TEST SAMPLES

TABLE 5

The temperature coefficient of the Geiger threshold is shown in Table 7. The acceptable rate is 0.05 volts per degree F.

As can be seen from Table 7 only one (1) detector would have not met the specification of 0.05 volts per degree F.

Figure 4 is a sample of the plateau data and starting voltage characteristics as given in Table 5.

Table 5 illustrates the test results demonstrating the initial starting voltage and pulse amplitudes measurements. A similar series of measurements were conducted on the same tube samples in excess of one month later (Table 8). It can be seen that no significant variation has occurred in either the starting voltage or the G-M tube pulse amplitude during the initial holding period.

Table 5 illustrates the initial plateau characteristics obtained on the test sample using the standard test circuit as shown. Initial measurements exhibit plateau length and slope characteristics that are within the requirements set down in Spec. SCS-415A.

Serial Number	Starting Voltage	Deviation from Required Vs.	Pulse Height at 500V	Deviation from Required Pulse Height
211234	417 volts	+17 volts	31 volts	OK
211259	423 volts	+23 volts	31 volts	OK
211241	425 volts	+25 volts	31 volts	OK
211250	425 volts	+25 volts	31 volts	OK
211240	432 volts	+32 volts	31 volts	OK
211252	427 volts	+27 volts	31 volts	OK
211254	415 volts	+15 volts	31 volts	OK
211245	433 volts	+33 volts	31 volts	OK
211239	430 volts	+30 volts	31 volts	OK
211251	422 volts	+22 volts	31 volts	OK
211244	419 volts	+19 volts	31 volts	OK
211246	426 volts	+26 volts	31 volts	OK

Starting Voltage and Pulse Height Deviation

Table 6

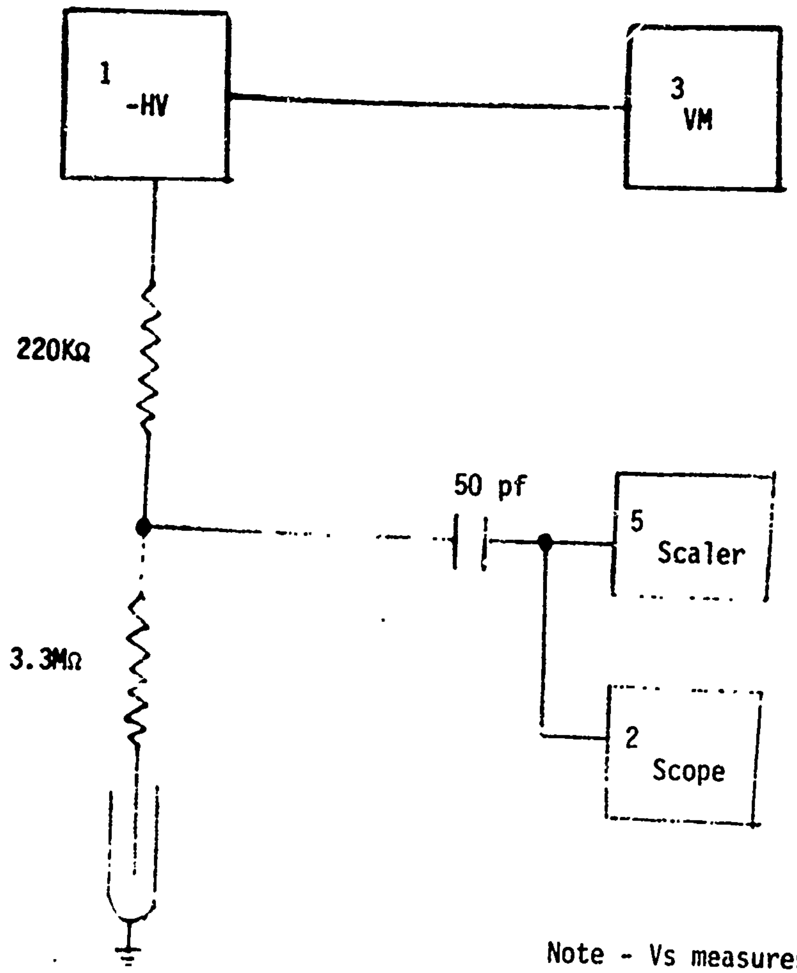
Serial Number	75	100	160	0	-50	Temp. Degree F
		Temperature Coefficient				Volts/Degree F
211234	417V	.03	.02	0	.01	
211159	423V	0	.01	.05	.03	
211241	425V	.04	.03	.04	.04	
211250	425V	.02	.02	.03	.05	
211240	432V	.04	.03	.01	0	
211252	427V	0	0	.01	.02	
211254	415V	0	.04	.05	.02	
211245	433V	.05	0	.02	.04	
211239	430V	.01	.05	.08	.1	
211252	422V	.02	.03	.04	.01	
211244	419V	.01	.02	.01	.01	
211246	426V	.01	.03	.05	.01	

Temperature Coefficient of Geiger Threshold

Table 7

FIGURE 4

TEST CIRCUIT FOR DATA SHOWN IN TABLES 5,6 and 8



Note - Vs measures at 1 volt pulse Ht.

Test Instruments

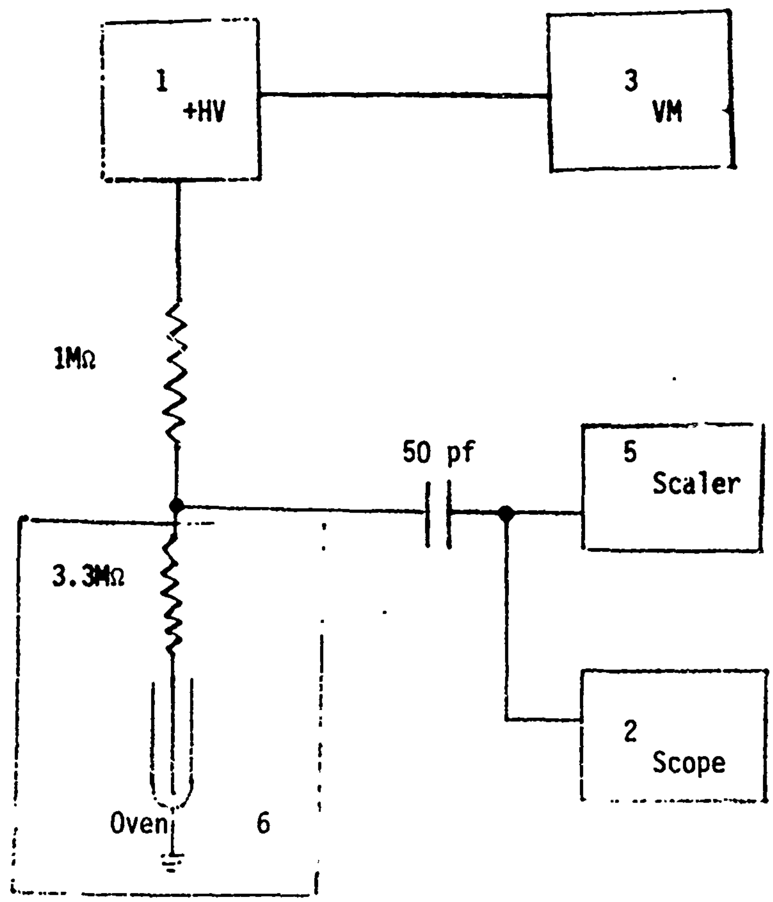
1. Fluke Model 412B supply.
2. Tektronix Model 531A Oscilloscope
3. Sensitive Research Model ESC Electrostatic Voltmeter
4. Cs^{137} Source.
5. Baird Atomic Model 135 Scaler Timer.

FIGURE 5

TEST CIRCUIT FOR PLATEAU CHARACTERISTICS

AND STARTING VOLTAGE OVER TEMPERATURE

RANGE -50°F to +160°F.



Test Instruments

1. Fluke Model 412B Supply
2. Tektronix Model 531A Oscilloscope
3. Sensitive Research Model ESD Electrostatic Voltmeter
4. Cs^{137} Source.
5. Baird Atomic Model 135 Scaler Timer.
6. Tenny Temperature Chamber.

Serial Number	Starting Voltage	Deviation from Required Vs.	Pulse Height at 500V	Deviation from Required Pulse Height
211234	421 volts	+21 volts	31 volts	OK
211259	429 volts	+29 volts	31 volts	OK
211241	429 volts	+29 volts	31 volts	OK
211250	426 volts	+26 volts	31 volts	OK
211240	435 volts	+35 volts	31 volts	OK
211252	432 volts	+32 volts	31 volts	OK
211254	408 volts	+8 volts	31 volts	OK
211245	437 volts	+37 volts	31 volts	OK
211239	432 volts	+32 volts	31 volts	OK
211251	426 volts	+26 volts	31 volts	OK
211244	422 volts	+22 volts	31 volts	OK
211246	430 volts	+30 volts	31 volts	OK

Starting Voltage and Pulse Height Deviation

Table 8

As can be seen initial tests show the units to have stable characteristics with the exception of serial number 211239 which failed to meet the low temperature requirement.

These units are now being aged in a high radiation field and will be tested periodically.

In reviewing the specifications of the SCS-415A the following has been accomplished.

3.2.1.1 The wall of the G-M tube is 446 stainless steel with a nominal density of 30.0 mg/cm^2.

3.2.2 The gas fill of Neon & Halogen admixture was 98.6% Ne, 1.4% Br to a pressure to 175 TORR.

3.3.2 Complete energy dependence tests were not made. Two samples from this group were sent to NUCOR and the following data was obtained.

Tube #1 Energy	Relative Response (Cs 137 Ref.)	Tube #2 Energy	Relative Response (Cs 137 Ref.)
Cs.137	1	Cs 137	1
85 Kev	1.1	85 Kev	1.05
129 Kev	.95	129 Kev	.88
187 Kev	1.07	187 Kev	1.0
222 Kev	1.1	222 Kev	1.05

3.3.3 The gamma sensitivity test was conducted at NUCOR on four samples and the following data was obtained using Cs 137.

Gamma Response

Serial Number	C/S/MR/HR@10MR	C/S/MR/HR@100MR
29257	1.1	1.0
29255	1.1	0.90
29237	1.0	0.91
29248	1.13	0.95

More detailed tests are being conducted.

3.3.3.1.1 The beta sensitivity to Bismuth 210 has not been measured. LND hopes to get data from the laboratory (CSTA, USAECOM) source for this group of engineering test samples.

3.3.3.2 Due to their construction the detectors are totally insensitive to light.

3.3.3.3. This test was not conducted on this group of engineering samples.

3.3.3.4 Hysteresis measurements were not conducted on this group of engineering test samples.

3.3.3.5 The sensitivity stability has not been completed since it takes 5000 hrs.

3.3.3.6 The temperature coefficient of the G-M tubes were measured as shown in Table. 7.

3.3.3.7 The background count rate was measured in a nuclear radiation shield consisting of 50MM of lead as an inner shield and 5MM of aluminum as an outer shield. All the detectors measured had a background count rate of ≤2CPM (Table 9.)

Serial No.	Background	Required Background
211234	1.9 CPM	2 CPM Max.
211259	2.0 CPM	2 CPM Max.
211241	1.7 CPM	2 CPM Max.
211250	1.8 CPM	2 CPM Max.
211240	1.7 CPM	2 CPM Max.
211252	1.6 CPM	2 CPM Max.
211254	1.5 CPM	2 CPM Max.
211245	1.7 CPM	2 CPM Max.
211239	1.8 CPM	2 CPM Max.
211251	1.5 CPM	2 CPM Max.
211244	1.8 CPM	2 CPM Max.
211246	1.4 CPM	2 CPM Max.

Background Count Rate on the Second Set of Engineering Test Samples

Table 9

SERIAL NO.	CAPACITANCE	MIN. ALLOWABLE CAPACITANCE
211234	1.8 PF	3 ± 10% PF MAX.
211259	1.7 PF	3 ± 10% PF MAX.
211241	1.9 PF	3 ± 10% PF MAX
211250	1.7 PF	3 ± 10% PF MAX
211240	1.8 PF	3 ± 10% PF MAX
211252	1.9 PF	3 ± 10% PF MAX
211254	1.8 PF	3 ± 10% PF MAX
211245	1.7 PF	3 ± 10% PF MAX
211239	1.9 PF	3 ± 10% PF MAX
211251	1.8 PF	3 ± 10% PF MAX
211244	1.7 PF	3 ± 10% PF MAX
211246	1.7 PF	3 ± 10% PF MAX

TUBE CAPACITANCE OF THE SECOND SET OF
ENGINEERING TEST SAMPLES

TABLE 10

3.4.2 THE TUBE CAPACITANCE WAS MEASURED ON EACH DETECTOR AND ALL UNITS MEASURED <2PF (TABLE 10).

3.4.3 THE RESPONSE CHARACTERISTICS MEASURED WERE:

1. GEIGER THRESHOLD.
2. TEMPERATURE COEFFICIENT.
3. GEIGER THRESHOLD TO KNEE.
4. OPERATING POINT.
5. PLATEAU LENGTH.
6. PLATEAU SHAPE.

1. THE GEIGER THRESHOLD DID NOT MEET THE REQUIREMENTS SINCE IT WAS FILLED TO START AT 450 ± 10 VOLTS NOT 400 VOLTS.

2. THE TEMPERATURE COEFFICIENT HAS BEEN PREVIOUSLY DISCUSSED AND ALL TUBES MET THIS REQUIREMENT EXCEPT ONE.

3. THE GEIGER THRESHOLD TO KNEE RESPONSE WAS MEASURED ON THE SECOND GROUP OF ENGINEERING TEST SAMPLES AND FOUND TO BE WITHIN SPECIFICATION.

4. THE PLATEAU OF EACH DETECTOR IS SUCH THAT THE OPERATING POINT OF 500 VOLTS ± 2 1/2 WAS MET FOR EVERY DETECTOR.

5. THE PLATEAU LENGTH FOR EACH DETECTOR WAS MEASURED TO BE GREATER THAN 200 VOLTS.

6. THE PLATEAU SLOPE MEASURED BETWWEN 450 AND 550 VOLTS WAS <15%/100 VOLTS FOR EACH DETECTOR.

SERIAL NO.	RISE TIME	MAX. RISETIME	DEVIATION
211234	4μSEC.	5 μSEC.	0
211259	4μSEC.	5 μSEC.	0
211241	4μSEC.	5 μSEC.	0
211250	3μSEC.	5 μSEC.	0
211240	5μSEC.	5 μSEC.	0
211252	4μSEC	5 μSEC.	0
211254	5μSEC.	5 μSEC.	0
211245	4μSEC.	5 μSEC.	0
211239	3μSEC.	5 μSEC.	0
211251	5μSEC.	5 μSEC.	0
211244	4μSEC.	5 μSEC.	0
211246	4μSEC.	5 μSEC.	0

PULSE RISE TIME FOR THE SECOND SET OF ENGINEERING TEST SAMPLES

TABLE 11

SERIAL NO.	DEAD TIME	MAX. ALLOW DEAD TIME	DEVIATION
211234	17 μSEC.	20 μSEC.	0
211259	18 μSEC.	20 μSEC.	0
211241	19 μSEC.	20 μSEC.	0
211250	20 μSEC.	20 μSEC.	0
211240	17 μSEC.	20 μSEC.	0
211252	20 μSEC.	20 μSEC.	0
211254	19 μSEC.	20 μSEC.	0
211245	19 μSEC.	20 μSEC.	0
211239	20 μSEC.	20 μSEC.	0
211251	19 μSEC.	20 μSEC.	0
211244	20 μSEC.	20 μSEC.	0
211246	18 μSEC.	20 μSEC.	0

PULSE DEAD TIME FOR THE SECOND SET OF ENGINEERING TEST SAMPLES

TABLE 12

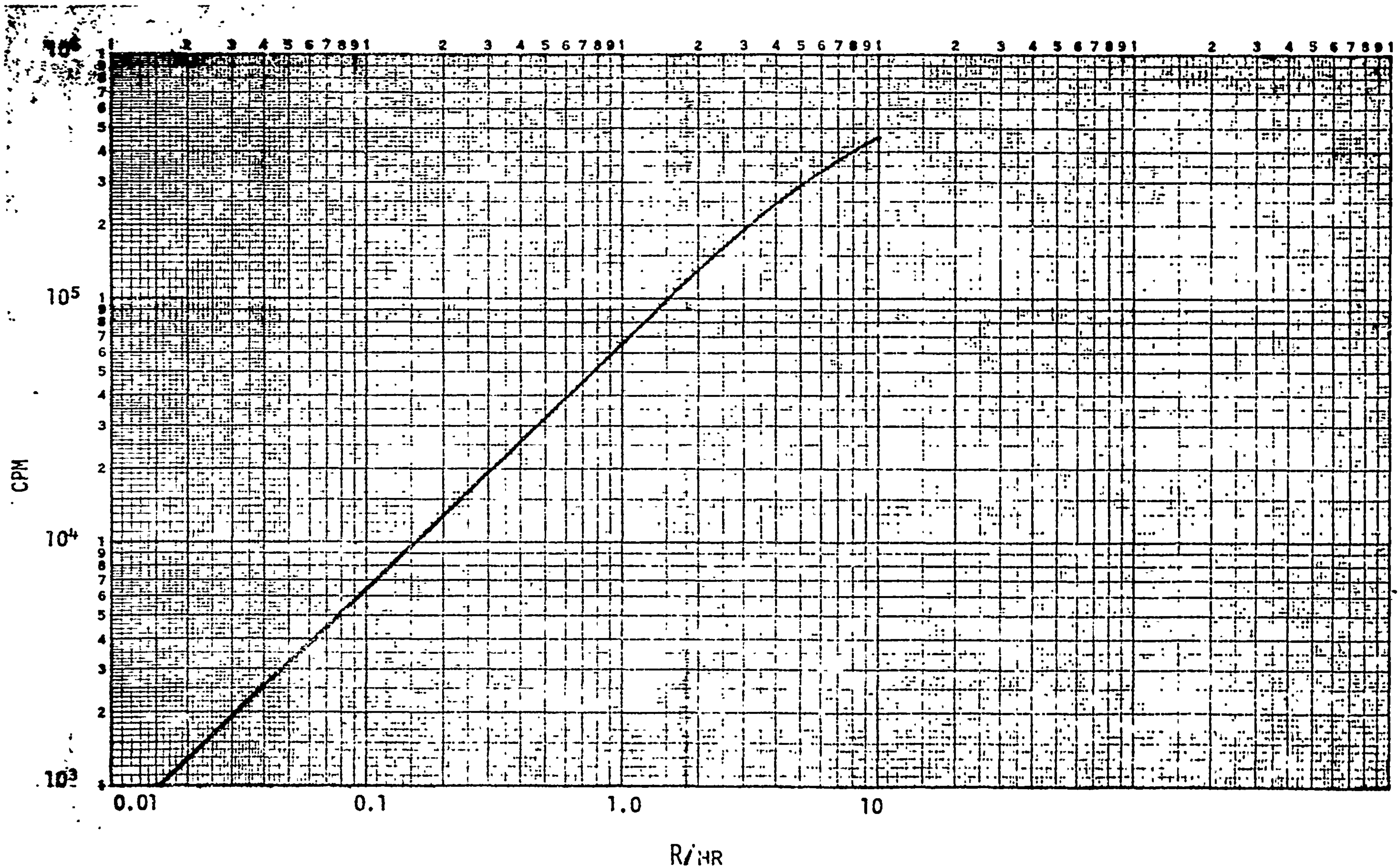


FIGURE 6

RESPONSE LINEARITY CURVE

3.4.4. The pulse shape was measured for each detector. All the units exhibited clean precise pulses.

3.4.4.1 The pulse rise time for each detector was measured to be <5 microseconds (Table 11).

3.4.4.2 The pulse dead time was measured to be approximately 20 microseconds. (Table 12)

3.4.4.3 The half amplitude recovery time as measured and found to be approximately 30 microseconds.

3.4.4.4 The pulse amplitude was measured at 500 volts as shown in Table 6 and found to be 30.0 ± 5 volts.

3.4.5 The response linearity was measured on one detector to be shown in Figure 6.

3.5 The service conditions were not tested on the second group of engineering test samples.

3.6 The burn in is being conducted on the second group of engineering test samples.

3.7 Material preparation is described in the earlier portion of this report.

3.8 Each tube had a serial number mechanically scribed on the cathode surface.

3.9 A calibration system is established at LND and was described with enclosures in the previous quarterly report.

4.5 ENVIRONMENTAL TESTS

A. ALL THE UNITS WERE PLACED IN A BELL JAR WHICH WAS PUMPED TO A VACUUM OF 10^{-4} TORR. THIS TEST WAS REPEATED 25 TIMES WITH NO ILL EFFECT ON THE TUBES.

B. EACH UNIT WAS SUBJECTED TO 175°F AS SHOWN IN TABLE 7 WITH NO ILL EFFECT.

C. EACH UNIT WAS SUBJECTED TO -50°F AS SHOWN IN TABLE 7. ONLY SERIAL NUMBER 211239 FAILED AT -50°F.

D. HUMIDITY TESTS WERE NOT CONDUCTED ON THE SECOND GROUP OF ENGINEERING TEST SAMPLES.

E. FUNGUS TESTS WERE NOT CONDUCTED ON THE SECOND GROUP OF ENGINEERING TEST SAMPLES.

F. VIBRATION AND SHOCK.

SAMPLE COUNTERS WERE SENT TO NUCOR AND THE FOLLOWING DATA WAS OBTAINED:

TUBES TESTED IN AN/VDR-1 CIRCUIT AND SUBJECT TO 2.2 G'S VIBRATION, .030" AMPLITUDE FOR 100 HRS. REFERENCE READINGS OBTAINED IN 6 R/HR Co^{60} RADIATION FIELD.

SERIAL NUMBER	CALIBRATION BEFORE VIBRATION	AFTER VIBRATION
29257	6.0 R/HR	6.2 R/HR
29255	6.0	5.9
29237	6.0	NO READING
29248	6.0	6.2

THE FOUR SAMPLES WERE EXPOSED TO THE STANDARD LOW FREQUENCY (55 HZ) 2.2 G'S VIBRATION FOR 100 HOURS. THREE OF THE FOUR SAMPLES REPRODUCED WITHIN THE LIMITS OF EXPERIMENTAL ERROR OF THE ORIGINAL REFERENCE READINGS. ONE TUBE FAILED DURING VIBRATION AS A RESULT OF A DAMAGED GLASS TO METAL SEAL. IN TESTING OF THE INSTRUMENT THE TUBE EXPERIENCED RESONANT FREQUENCIES THAT DAMAGED THE TUBULATION. THIS WAS DUE TO IMPROPER MOUNTING IN THE INSTRUMENT.

CONCLUSION

THE INSTABILITY OF THE FIRST GROUP OF ENGINEERING TEST SAMPLES WAS EVIDENT FROM SEVERAL OF THE TESTS CONDUCTED. IT WAS OBSERVED THAT THE STARTING VOLTAGE SHOWED A CONTINUAL DECREASE WITH EXTENDED TIME WHICH ULTIMATELY MANIFESTS AS CONTINOUS DISCHARGE, SPURIOUS COUNTS OR OSCILLATION AND LEAKING TUBES.

FROM THE DATA RESULTS SHOWING GRADUAL DEGRADATION OF PERFORMANCE IT IS EVIDENT THAT THE QUENCHING AGENT IN EACH OF THESE UNITS HAS BEEN EITHER CONTAMINATED OR ABSORBED.

THE SECOND GROUP OF ENGINEERING TEST SAMPLES WERE FABRICATED USING THE PROCEDURE REPORTED. THE AIM OF THE SECOND GROUP WAS TO ELIMINATE STARTING VOLTAGE INSTABILITY AND ACHIEVE PULSE HEIGHT AND GAMMA RESPONSE PARAMETERS WITH TIME AND ENVIRONMENTAL EXTREMES.

ANALYSIS OF THE DATA OBTAINED IN TESTING THE SECOND GROUP OF ENGINEERING SAMPLES INDICATES THAT THE STARTING VOLTAGE CORRECTION IN THE ASSEMBLY PROCEDURE WAS APPROXIMATELY CORRECT. THE STARTING VOLTAGES RANGED FROM 417 TO 433 VOLTS INITIAL. THIS LEVEL WILL PERMIT SOME DECREASE IN STARTING VOLTAGE AS IS NORMALLY OBSERVED IN G-M TUBE AND WILL STILL PERMIT EXTENDED USEFUL LIFE IN THE AN/VDR-1 EQUIPMENT.

THE PLATEAU LENGTH MEASUREMENTS WERE MADE MAINLY AS A REFERENCE TO OBSERVE THE EXTENT OF THE TUBE PLATEAU LENGTH.

THE MAXIMUM PLATEAU LENGTH REQUIRED FOR AN/VDR-1 OPERATION IS 600 VOLTS MAXIMUM. ALL TUBES HAD SUFFICIENT PLATEAU LENGTH.

RESULTS OF TESTING CONDUCTED BY NUCOR IN THE AN/VDR-1 EQUIPMENT INDICATED THAT THE TUBE OVER A 45 DAY PERIOD OPERATES SATISFACTORILY. THE CALIBRATION TEST REVEALED THAT ALL TUBES CALIBRATED WHEN OPERATED IN THE AN/VDR-1 OVER THE REQUIRED RANGE OF OPERATION. THIS REQUIRED THAT THE TUBES BE OPERATED IN THE DC RANGE (1R/HR.) AND WITH A SUPERIMPOSED HIGH VOLTAGE PULSE (IN THE 10,100 AND 1000 R/HR. RANGES). SATISFACTORY TRACKING AND CALIBRATION ACCURACY WAS OBTAINED WHEN EACH TUBE WAS STANDARDIZED AT 60% OF FS ON EACH RANGE.

VERIFICATION OF STARTING VOLTAGE STABILITY WAS CONDUCTED OVER A 40 DAY PERIOD. THE RESULTS OF THIS TEST ARE NOT YET CONCLUSIVE; THE TEST WILL BE CONTINUED TOWARD OBTAINING EXTENDED LIFE DATA AND A 6 MONTH STABILITY INDEX.

THE DEPENDENCE OF STARTING VOLTAGE ON AMBIENT TEMPERATURE WAS MEASURED. THE TUBES WERE OPERATED AT THE REQUIRED TEMPERATURE EXTREMES AND STARTING VOLTAGE VARIATION OBSERVED. THIS WAS CHECKED IN THE AN/VDR-1 CIRCUIT. IT IS TO BE NOTED, HOWEVER, THAT SEVERE TEMPERATURE DEPENDENCE HAS BEEN OBSERVED ON OTHER SAMPLES AND ADDITIONAL TESTING IS REQUIRED AS THE TUBES AGE BEFORE SIGNIFICANT CONCLUSIONS CAN BE DRAWN.

FURTHER TESTING OF THE SECOND GROUP OF ENGINEERING TEST SAMPLES IS REQUIRED BEFORE A NEW MANUFACTURING PROCEDURE IS DRAWN UP FOR THE THIRD GROUP OF ENGINEERING TEST SAMPLES.

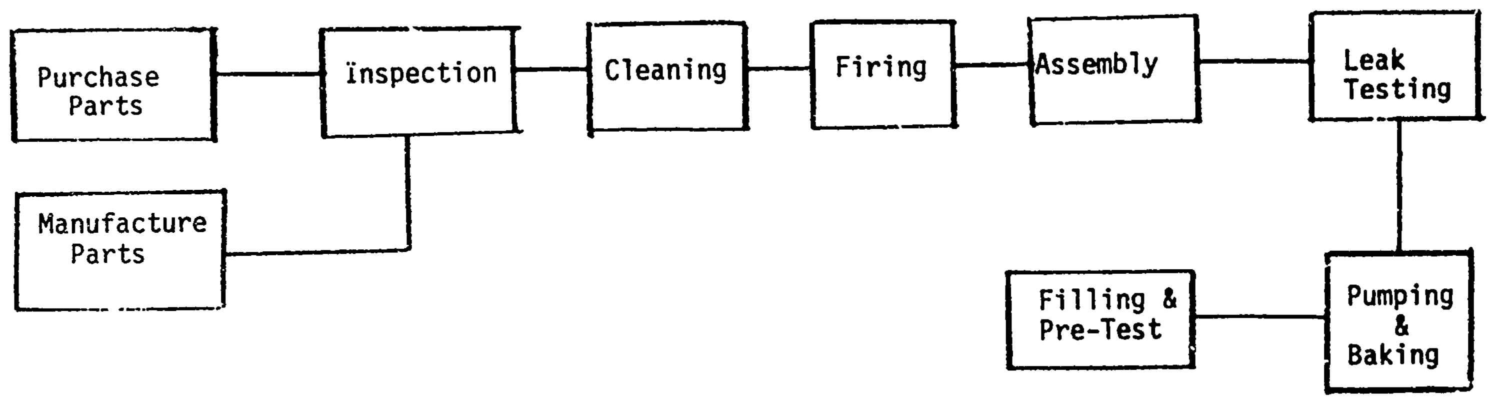


Figure 7

FLOW CHART OF MANUFACTURING PROCESS

PROGRAM FOR THIRD QUARTER

ALTHOUGH ALMOST ENOUGH DATA IS AVAILABLE PRESENTLY TO COMPLETE A PRELIMINARY DESIGN FOR THE "THIRD GROUP OF ENGINEERING TEST SAMPLES" THE FOLLOWING CHARACTERISTICS WILL BE FURTHER EVALUATED IN THE THIRD QUARTER BEFORE WORK BEGINS ON THE THIRD GROUP OF ENGINEERING TEST SAMPLES.

1. COMPLETE ANALYSIS OF STARTING VOLTAGE DEVIATION WITH TIME.
2. STARTING VOLTAGE SHIFT WITH TEMPERATURE.
3. ANALYSIS OF BETA SENSITIVITY.
4. ANALYSIS OF OPERATION AFTER EXTENDED PERIODS IN HIGH RADIATION FIELDS.

AFTER THOROUGH ANALYSIS OF THE ABOVE DATA AND AN INTERFACE WITH THE GROUP AT FORT MONMOUTH AND NUCOR, LND WILL DESIGN A NEW PUMP AND FILL SCHEDULE AND MANUFACTURE THE "THIRD GROUP OF ENGINEERING TEST SAMPLES".

APPENDIX I

OXYGEN FIRING PROCEEDURE

1. Take chemically cleaned and etched components and place them in vacuum firing jar.
2. Pump down to 10^{-6} torr.
3. Activate RF generator and heat components to $900^{o}C$.
4. When all components have been thoroughly outgassed admit ultra pure oxygen (760 torr) and keep heat on for 1 minute.
5. Allow to cool in oxygen atmosphere.

APPENDIX 2

GLOSSARY

AVALANCHE THE CUMULATIVE PROCESS IN WHICH CHARGED PARTICLES ACCELERATED BY AN ELECTRIC FIELD PRODUCE ADDITIONAL CHARGED PARTICLES THROUGH COLLISION WITH NEUTRAL GAS MOLECULES OR ATOMS.(FROM IEEE STANDARDS PUBLICATION 160)

BACKGROUND COUNTS (RADIATION COUNTERS). COUNTS CAUSED BY RADIATION COMING FROM SOURCES OTHER THAN THAT TO BE MEASURED. (FROM IEEE STANDARDS PUBLICATION 160).

COUNT (RADIATION COUNTERS). A SINGLE RESPONSE OF THE COUNTING SYSTEM. SEE ALSO TUBE COUNT. (FROM IEEE STANDARDS PUBLICATION 160).

COUNTER TUBE, EXTERNALLY QUENCHED A RADIATION COUNTER TUBE THAT REQUIRES THE USE OF AN EXTERNAL QUENCHING CIRCUIT TO INHIBIT RE-IGNITION. (FROM IEEE STANDARDS PUBLICATION 160).

COUNTER TUBE, GAS-FILLED, RADIATION A GAS TUBE USED FOR DETECTION OF RADIATION BY MEANS OF GAS IONIZATION (FROM IEEE STANDARDS PUBLICATION 160).

<u>Counter Tube, Gas-Flow</u> A radiation -counter tube in which an appropriate atmosphere is maintained by a flow of gas through the tube. (From IEEE Standards Publication 160).

<u>Counter Tube, Geiger-Muller.</u> A radiation-counter tube operated in the Geiger-Muller region,(From IEEE Standards Publication 160.)

<u>Counter Tube, Self-Quenched</u> A radiation-counter tube in which re-ignition of the discharge is inhibited by internal processes. (From IEEE Standards Publication 160).

<u>Counting Efficiency</u> (Radiation Counter Tubes) The ratio of the number of counts to the total number of ionizing particles or quanta entering the sensitive volume when the counting rate is so low that the dead time correction is unnecessary.

<u>Counting Rate Versus Voltage Characteristic</u> The relation between counting rate and voltage applied to a radiation-counter tube for constant radiation intensity.(From IEEE Standards Publication 160)

<u>Dead Time</u> (Radiation Counters) The time interval after the start of an essentially full amplitude pulse, during which a radiation counter is insensitive to further ionizing events. See also Recovery Time.

<u>EFFICIENCY</u> (RADIATION COUNTER TUBES) THE PROBABILITY THAT A TUBE COUNT WILL TAKE PLACE WITH A SPECIFIED PARTICLE OR QUANTUM INCIDENT IN A SPECIFIED MANNER. (FROM IEEE STANDARDS PUBLICATION 160).

<u>GAS AMPLIFICATION</u> (RADIATION-COUNTER TUBES) SEE GAS MULTIPLICATION FACTOR.

<u>GAS MULTIPLICATION FACTOR</u> (RADIATION COUNTER TUBES) THE RATIO OF 1) THE CHARGE COLLECTED FROM THE SENSITIVE VOLUME TO 2) THE CHARGE PRODUCED IN THIS VOLUME BY THE INITIAL IONIZING EVENT.

<u>GEIGER-MULLER REGION</u> (RADIATION COUNTER TUBES) THE RANGE OF APPLIED VOLTAGE IN WHICH THE CHARGE COLLECTED PER ISOLATED COUNT IS INDEPENDENT OF THE CHARGE LIBERATED BY THE INITIAL IONIZING EVENT (FROM IEEE STANDARDS PUBLICATION 160)

<u>GEIGER-MULLER THRESHOLD</u> (RADIATION COUNTER TUBES) THE LOWEST APPLIED VOLTAGE AT WHICH THE CHARGE COLLECTED PER ISOLATED TUBE COUNT IS SUBSTANTIALLY INDEPENDENT OF THE NATURE OF THE INITIAL IONIZING EVENT (FROM IEEE STANDARDS PUBLICATION 160)

<u>HALF-AMPLITUDE RECOVERY TIME</u> (GEIGER-MULLER COUNTERS) THE TIME INTERVAL FROM THE START OF A FULL AMPLITUDE PULSE TO THE INSTANT A SUCCEEDING PULSE CAN ATTAIN AN AMPLITUDE OF 50 PERCENT OF THE MAXIMUM AMPLITUDE OF A FULL-AMPLITUDE PULSE.

INITIAL IONIZING EVENT (RADIATION COUNTER TUBES) AN IONIZING EVENT THAT INITIATES A TUBE COUNT. (FROM IEEE STANDARDS PUBLICATION 160).

MULTIPLE TUBE COUNTS (RADIATION COUNTER TUBES) SPURIOUS COUNTS INDUCED BY A PREVIOUS TUBE COUNTS. (FROM IEEE STANDARDS PUBLICATION 160)

PLATEAU (RADIATION COUNTER TUBES) THE PORTION OF THE COUNTING-RATE-VERSUS-VOLTAGE CHARACTERISTIC IN WHICH THE COUNTING RATE IS SUBSTANTIALLY INDEPENDENT OF THE APPLIED VOLTAGE. (FROM IEEE STANDARDS PUBLICATION 160).

PLATEAU LENGTH (RADIATION COUNTER TUBES) THE RANGE OF APPLIED VOLTAGE OVER WHICH THE PLATEAU EXTENDS. (FROM IEEE STANDARDS PUBLICATION 160).

PLATEAU SLOPE (RADIATION COUNTER TUBES) THE SLOPE OF THE PLATEAU EXPRESSED AS THE PERCENTAGE CHANGE IN COUNT RATE PER 100-VOLT CHANGE IN APPLIED VOLTAGE.

QUENCHING (RADIATION COUNTER TUBES). THE PROCESS OF TERMINATING A DISCHARGE IN A RADIATION-COUNTER TUBE BY INHIBITING RE-IGNITION. (FROM IEEE STANDARDS PUBLICATION 160).

RADIATION (NUCLEAR) IN NUCLEAR WORK , THE USUAL MEANING OF RADIATION IS EXTENDED TO INCLUDE MOVING NUCLEAR PARTICLES, CHARGED OR UNCHARGED. (FROM IEEE STANDARDS PUBLICATION 160)

RECOVERY TIME (GIEGER-MULLER COUNTERS) THE MINIMUM TIME FROM THE START OF A COUNTED PULSE TO THE INSTANT A SUCCEEDING PULSE CAN ATTAIN A SPECIFIED PERCENTAGE OF THE MAXIMUM AMPLITUDE OF THE COUNTED PULSE. (FROM IEEE STANDARDS PUBLICATION 160)

RE-IGNITION (RADIATION COUNTER TUBES) THE GENERATION OF SPURIOUS COUNTS BY ATOMS OR MOLECULES EXCITED OR IONIZED IN THE DISCHARGE ACCOMPANYING A COUNT.

RESOLVING TIME (RADIATION COUNTERS) THE MINIMUM ACHIEVABLE PULSE SPACING BETWEEN COUNTS. (FROM IEEE STANDARDS PUBLICATION 160)

Note: This quantity is a property of the combination of the tube and recording circuit.

RISE TIME (RADIATION COUNTER TUBES) THE INTERVAL BETWEEN THE INSTANTS AT WHICH THE INSTANTANEOUS VALUE FIRST REACHES SPECIFIED LOWER AND UPPER LIMITS, NAMELY, 10 AND 90 PERCENT OF THE PEAK PULSE VALUE.

SENSITIVE VOLUME (RADIATION COUNTER TUBES) THAT PORTION OF THE TUBE RESPONDING TO SPECIFIC RADIATION. (FROM IEEE STANDARDS PUBLICATION 160).

<u>SPURIOUS COUNT</u> (RADIATION COUNTER TUBES) A COUNT CAUSED BY AND EVENT OTHER THAN THE PASSAGE INTO OR THROUGH THE COUNTER TUBE OF THE IONIZING RADIATION TO WHICH IT IS SENSITIVE.

<u>TUBE COUNT</u> (RADIATION COUNTER TUBES) A TERMINATED DISCHARGE PRODUCED BY AN IONIZING EVENT. (FROM IEEE STANDARDS PUBLICATION 160)